

PERIODICITY IN OVIPOSITION OF *OSTRINIA* *NUBILALIS* (HBN.)¹

(LEPIDOPTERA: PYRAUSTIDAE)²

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ABSTRACT

A perfect 24-hr rhythm was found in the oviposition of European corn borer moths exposed to the fluctuations of the natural environment, with a peak of egg laying at 10 pm Central Standard Time. On the other hand, corn borer moths held in constant darkness with unchanging temperature and humidity deposited eggs during the entire 24-hr daily period. However, a circadian rhythm in oviposition was revealed by regular peaks of maximal egg laying. There was a coincidence of the peaks of maximum oviposition in both groups of experimental insects at the start and at the end of their adult lives. During the middle portion of the adult lives of the insects held under constant conditions, the peak of oviposition varied from that of insects exposed to natural environmental conditions. In addition to the circadian variations, there appears to exist also a relatively precise 24-hr rhythm, which may or may not be intrinsically timed.

The European corn borer, *Ostrinia nubilalis*, is nocturnal and, in a natural environment, lays all of its eggs during the night. Stirrett et al. (1934) and Stirrett (1938) have reported observations of corn fields in Ontario, Canada, which indicated that most of the oviposition under natural conditions takes place before the early morning hours.

The present study compared the times of oviposition of female moths of the European corn borer kept under controlled conditions of light, temperature, and humidity with those of other individuals which were exposed to the fluctuations of the natural environment. The experimental insects in this study were from a wild population of the corn borer which infests corn in southern Minnesota. Infested corn was cut in the fall of the year and placed in large emergence cages. In the spring, the imagos emerged from this corn. These moths were collected with particular care to avoid injury and transferred to oviposition cages on the morning following their emergence from pupal cases. Seventy-five moths of each sex were placed in each oviposition cage. Figure 1 shows the construction of an oviposition cage. This method of obtaining egg masses has been described by Patch and Pierce (1933) and, with slight modifications, has been used for securing corn borer egg masses by various research groups since that time. With this technique, the eggs are deposited on the under side of wax paper placed on the upper side of the cages.

A preliminary laboratory study of oviposition indicated that a majority of the egg masses were deposited shortly before midnight. This suggested a rhythmicity in oviposition. The possibility of a periodicity in egg laying was tested with an experimental group of 600 European corn borer moths. Three hundred moths (a total of 150 female moths) were confined in two oviposition cages which were kept in darkness at 30 C and a relative humidity of 95 per cent. Two other cages, holding an identical number of moths, were exposed to the fluctuations of the natural environment. These cages were placed in the shade of vegetation consisting of plant species (*Setaria glauca* and *Agropyron repens*) under which the

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corn borer moths had been observed, in their natural habitats, to remain quiescent during the day.

The wax paper, on which the eggs were deposited, was changed from all cages at 2-hr intervals on the even hours U.S.A. Central Standard Time. With this procedure it was possible to record the oviposition throughout the day in both groups of moths. At the times when the wax papers were changed, the moths were given water, but they had no food. The egg masses were counted and the number served as evidence of the number of times oviposition had taken place during each 2-hr interval. The wax paper was changed on those cages held at constant conditions during a period of 1 min with illumination from a red $7\frac{1}{2}$ -watt incandescent light bulb which was located 3 m from the cages (unpublished data of the authors indicate that corn borer moths do not respond to this light at a distance of 6 cm.)

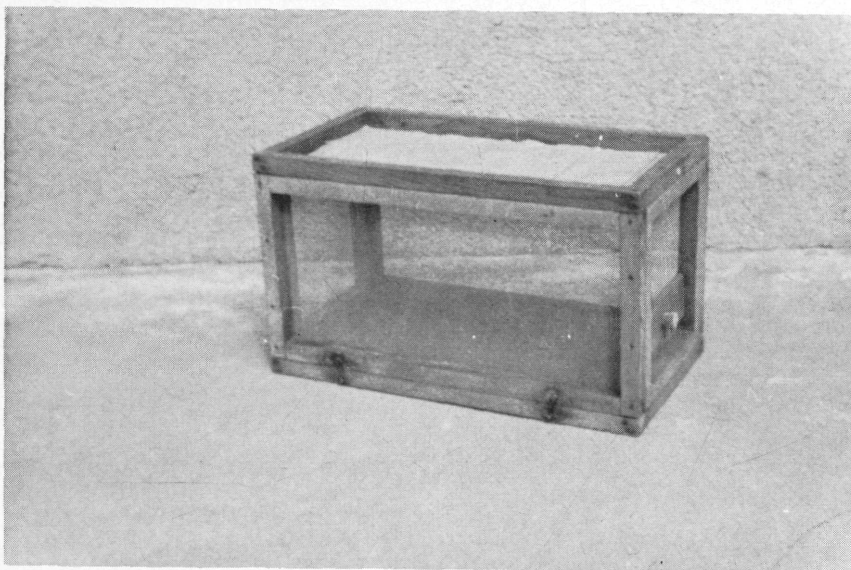


FIGURE 1. An oviposition cage constructed of wood and copper screen. The eggs were deposited on wax paper laid on the upper side. Dimensions were 30 cm x 30 cm x 90 cm.

The number of egg masses produced during each 2-hr period throughout the adult life of the corn borers was recorded. The data are shown in graphic form in figure 2. It is apparent that the moths exposed to the natural changes of the environment exhibited a very marked periodicity in the time of oviposition, with a peak of egg laying at 10 PM Central Standard Time. There was also a strong response to changes in humidity, but this response did not affect the periodicity. During the evening of day two and day three, there were rainstorms. On the night of day five there was a thunderstorm with hail and rain. These periods of precipitation and high humidity were marked by a tremendous increase in both the size and number of egg masses. The importance of moisture in the biology of the corn borer has been documented by Barlow and Muchmore (1963). Apparently the act of oviposition occurs more frequently during periods of natural rainfall and high humidity.

The data of Barlow and Muchmore show clearly that sprays of water increase

the number of eggs per female when compared to populations of corn borers which were deprived of water. In the present study, however, the response of increased egg laying occurred even though all moths in all the cages were given a spray of water every 2 hr when the oviposition paper was changed. No dramatic increase in oviposition was observed on the part of moths kept at 95 per cent relative humidity when they were given a spray of water, nor by moths exposed to the fluctuations of the environment when they were given a spray of water. Only when natural precipitation moistened the cages were the eggs larger, or more frequently deposited. It would seem that this is a normal response which causes increased oviposition during or shortly after rainfall and is triggered by the saturated humidity which follows periods of low humidity. As a result of this association of egg laying with natural precipitation, the delicate eggs would be exposed to desiccation much less than if they were deposited at some other time. Data

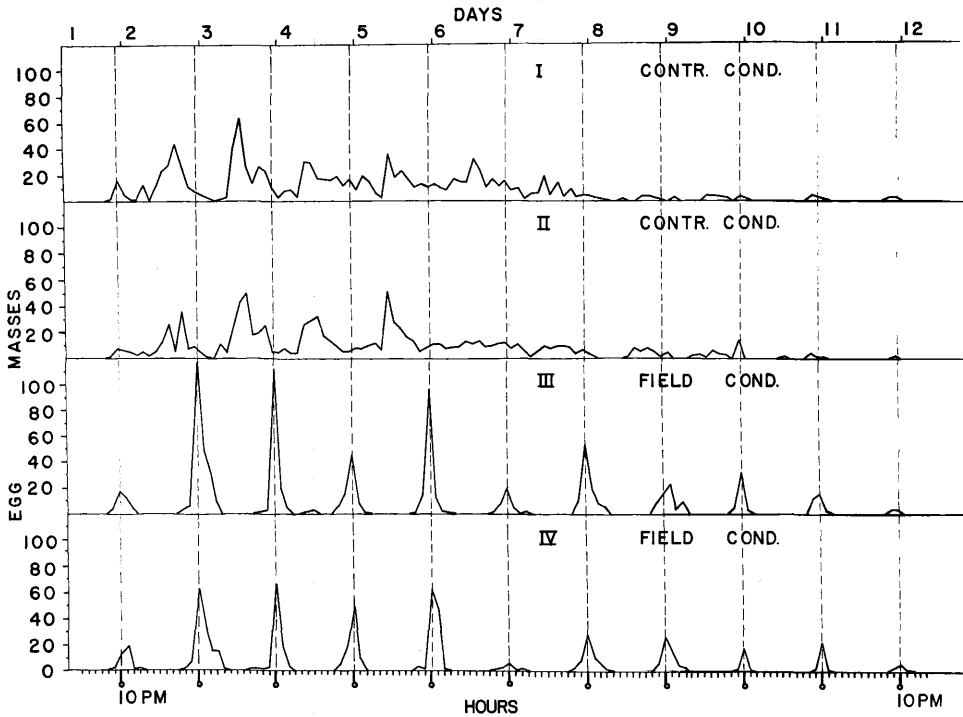


FIGURE 2. Graphs of the numbers of egg masses deposited in the four cages (two cages held at controlled conditions, and two cages exposed to natural field conditions). 10PM each day is marked by the symbol \circ .

of the authors (to be presented in a separated publication) show that moisture is imbibed by corn borer eggs either from contact with free moisture such as dew or guttation droplets or from atmospheres which are saturated with moisture.

Records of the temperature and humidity were taken with hygrothermographs in the vicinity of the cages which were kept out of doors, and also in the chamber where environmental conditions were held constant. The records of external temperature and humidity showed daily fluctuations which were much less exact in their periodicity than the very regular rhythm in oviposition displayed by the insects exposed to the natural environment. The daily change in light intensity may be a cue which governs the periodicity of oviposition in corn borers exposed to natural conditions.

The moths kept under constant conditions exhibited on the first day a peak of egg-laying at the same time as for those under the field conditions. However, the time of maximum oviposition occurred about 4 hr earlier on each of the two succeeding days suggesting a persisting rhythm with a period of about 20 hr (fig. 2). From the fourth to the seventh day, the peaks appeared to occur near noontime instead of 10 PM, displaying an average period close to 24 hr. Cloudsley-Thompson (1959) has reported that night-active animals have rhythms accelerated by constant darkness. For later discussion of this, see also Cloudsley-Thompson (1961) and Biological Clocks—Cold Spring Harbor Symposia in Quantitative Biology (1960). This reaction may have caused the observed movement of the peak of oviposition to an earlier time each day. By the ninth day, however, a peak in egg-production in the moths in the controlled conditions had reappeared at 10 PM, and persisted through the ninth, tenth and eleventh days synchronized with the daily peak of the moths under the field conditions.

Moths kept under constant conditions exhibited a peak of egg laying each day, but oviposition during the time of maximum productivity in the lives of the insects rarely came to a complete halt. Apparently unvarying conditions of darkness, temperature, and humidity tended to obfuscate the periodicity shown by moths exposed to the natural environment. Still, moths held under controlled conditions exhibited peaks of oviposition which coincided at the start and end of the study with the peaks of oviposition by moths held outdoors. This suggests strongly that, even together with the possible 20-hr rhythmic component evident during the first 3 days and the observed lability of the time of a daily peak of egg-laying in the moths in the controlled environment evident by its noon value from the fourth to the seventh day, there remained an apparently precise 24-hr rhythm of egg laying. The time of the daily peak in this 24-hr rhythm seems to have been unaffected by the conspicuous diffusion of the times of egg-laying over the whole day which was observed throughout the first week. Such a precise 24-hr rhythm may be timed by an inherent or endogenous periodicity, but as pointed out by Bunning (1964), when an exact 24-hr rhythm is found under such constant conditions, it is probable that some still unrecognized environmental factor is operating. It would seem that light opposes and represses the act of oviposition, while darkness, saturated humidity, and/or free moisture promote egg laying. All the stimuli which are favorable to oviposition are present at night in a corn field: darkness, dew, and water of guttation on the corn leaves, as well as increased humidity.

The longevity of the 600 moths used in this study was within the limits of the usual life expectancy of 11,021 moths reared from the same population of larvae. Death was first observed in both groups of experimental insects on the same day, and although 2 moths from the group kept under constant conditions lived a day longer than the moths exposed to the fluctuations of the natural environment, they produced no eggs on the final day of their life.

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